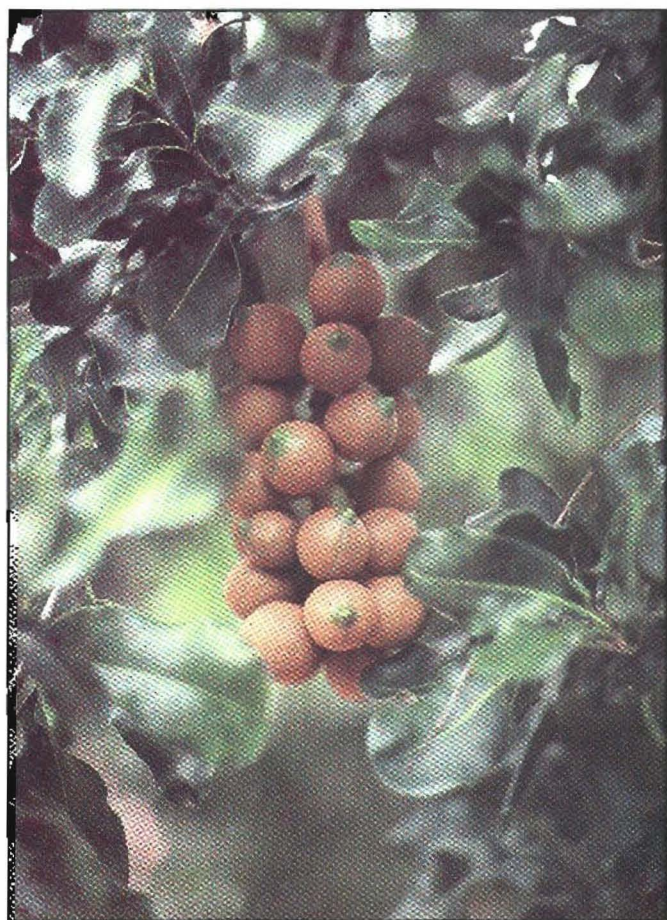


COMMON PROBLEMS OF MACADAMIA NUT IN HAWAII

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and Howard H. Hiraie**

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ITHAHR UNIVERSITY OF HAWAII



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INTRODUCTION

Macadamia nut growers in Hawaii frequently see striking or odd things in their orchards. What's this? Is this a problem? Is my tree sick? Will this lower yield? Even the experienced grower might miss the less obvious signs of problems that will seriously lower an orchard's productivity.

This bulletin responds to a specific request in Macadamia Industry Analysis Number 4, 1988, action 1.4: "Publish a pictorial chart showing 99% of the common macadamia problems, despite cause, i.e., pest, disease, nutrient imbalance, improper pesticide and fertilizer application." Growers at the 28th Annual Meeting of the Hawaii Macadamia Nut Association were surveyed on their common macadamia problems, both minor and major, that new growers should know about. The problems identified by growers are the basis for the following discussion of common macadamia problems in Hawaii.

Unlike most bulletins that deal with problems and their causes, this one is organized by symptoms and their location on the tree. Each problem is described briefly with accompanying photographs. These show outstanding features for recognizing the problem in the orchard. References for other publications and solutions (if known) are given.

PROBLEMS WITH THE SOIL

How to Collect a Soil Sample

Soil sampling is recommended before planting an orchard and annually when collecting a leaf sample. It is important to collect the sample properly to avoid contaminating it with fertilizer on top of the soil or on your tools. Following the fertilizer recommendations from a soil analysis is the most important way to avoid nutritional problems.

Solution

Soil samples should be taken from a zone 2 feet from the trunk out to the edge of the canopy or drip zone. Using a clean shovel that hasn't been used for applying fertilizer, scrape away the surface leaves and soil until you reach the small and sometimes stubby macadamia roots (Fig. 1). Collect soil from this depth down another 4 to 6 inches using a clean plastic glove or bag over your hand (Fig. 2). Put a cup or more of soil into a clean plastic bag (Fig. 3).

If you have just a few acres, samples from three or more trees throughout the orchard should be collected and thoroughly mixed together. The soil sample should weigh at least a pound for it to be analyzed for phosphorus, potassium, calcium, magnesium, and pH. If you have an area that you suspect has nutritional problems, collect two separate samples, one from this area and one where tree growth is normal.

Label the sample bag and complete the information forms required by the analytical laboratory. Check with your extension agent for companies that do soil analysis.



Fig. 1. Scrape away weeds, leaves, and topsoil down to macadamia roots. H. C. Bittenbender photo.



Fig. 2. Loosen soil and rocks 4 to 6 inches below the top of the macadamia root zone. H. C. Bittenbender photo.



Fig. 3. Put soil (not rocks) in a clean plastic bag. H. C. Bittenbender photo.

PROBLEMS ON ROOTS AND TRUNKS

Macadamia Root Rot

This fungus, *Kretzschmaria clavus*, attacks the roots and lower trunk of macadamia nut trees, eventually killing the tree. Orchards in high rainfall areas near forests or on recently cleared forest land are most susceptible to this disease. The disease doesn't spread rapidly or appear to be a major problem, however.

Besides poor growth and few leaves, the obvious symptom is a black fungus with a smooth or slightly knobby appearance on the lower trunks or exposed roots (Fig. 4). Young shoots (suckers) growing around the trunk are also a symptom (Fig. 5). If the tree is cut down, look for black lines and gray areas in the trunk's cross and long sections (Figs. 6 and 7).

Solution

No fungicides are registered nor likely to be effective. Dead trees and roots should be removed from the orchard. Don't plant in the same hole or nearby until the diseased roots have decomposed.

Remove forest trees completely when preparing new orchard sites in forested areas. Don't bury or chip trees in the orchard, as they may be diseased and infect the orchard. Don't leave large rocks near the base of a tree when planting. As trees grow, cuts and scrapes on trunks and roots caused by rocks or other mechanical injuries provide entry for this disease.



Fig. 4. Spore-producing stage on the bark or surface-exposed roots. Photo courtesy of Wayne Nishijima.

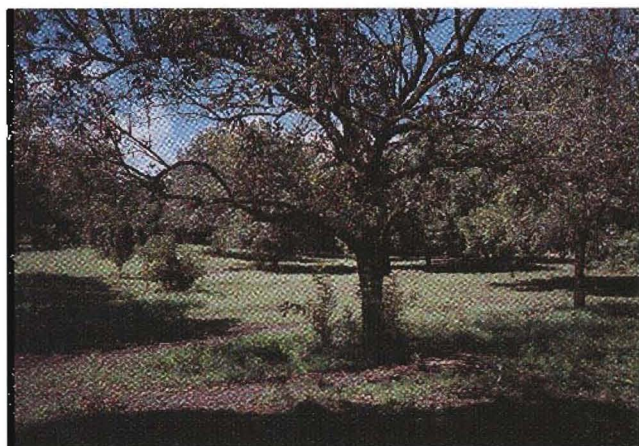


Fig. 5. An infected tree is slowly dying. Note typical production of new shoots around base of tree. H. C. Bittenbender photo.



Fig. 6. Trunk of infected tree cut lengthwise shows gray diseased area. Howard H. Hira photo.

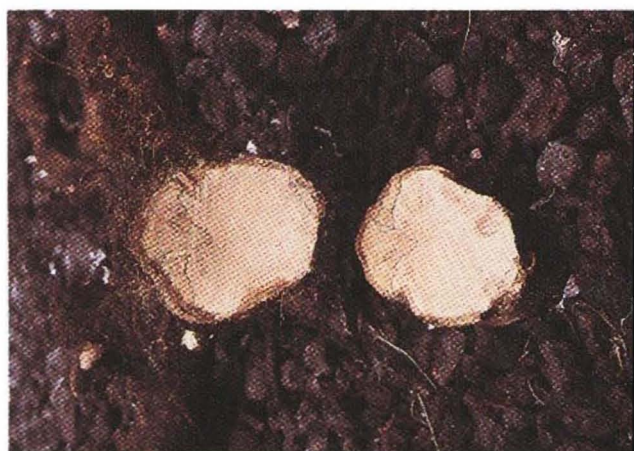


Fig. 7. Infected roots cut crosswise show the edge of the infected area as black lines. Photo courtesy of Wen Ko.

Trunk Canker

This is an uncommon disease. The fungus *Phytophthora cinnamomi* can infect trunks at or near the ground, generally through a wound. The infected part of the trunk appears cracked and callused or flattened and produces a dark gummy sap (Fig. 8). Tree growth is reduced and the tree may die.

Solution

No fungicides are registered. Preventive measures include planting on well-drained sites, not planting too deeply, and not cutting or wounding the trunk near the ground.

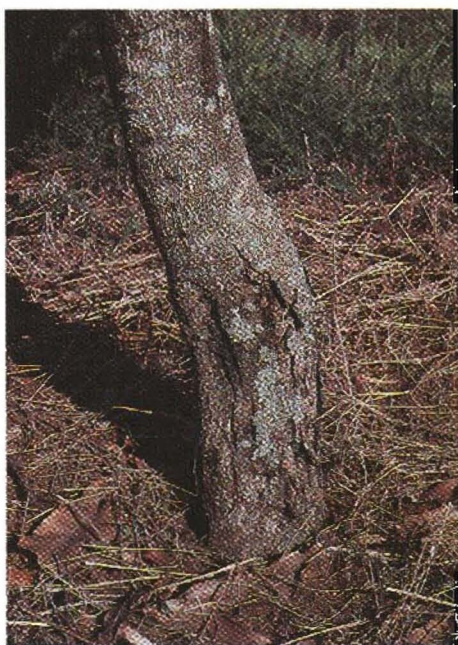


Fig. 8. Trunk of *Phytophthora*-infected trunk shows flattened canker areas with vertical cracking and dark gummy sap on bark. Photo courtesy of Wayne Nishijima.

Inverted Bottleneck-shaped Trunks

The inverted bottleneck becomes apparent when the trunk of the scion (top part of a grafted tree) grows wider than the rootstock below the graft union (Fig. 9). This is primarily a problem in older orchards where smooth-shell cultivars are grafted onto rough-shell rootstocks. Newer orchards have smooth-shell rootstocks, so the inverted bottleneck isn't a problem.

Biochemical incompatibility between the two species—the rough shell and the smooth shell—is the cause. Symptoms don't develop immediately, and not all trees with rough-shell rootstocks will develop symptoms.

Frequently, affected trees will break at the graft union or the yields will decrease over time.

Solution

Never plant trees grafted onto rough-shell rootstocks. If your trees have this problem now, plant three or four smooth-shell seedlings around the tree. Graft a 1/2-inch-diameter or larger seedling onto the smooth-shell section of the trunk (above the graft union) with an approach graft (Fig. 10). Bond 23 produces vigorous seedlings, but any healthy smooth-shell seedlings will do. Alternatively, if the tree has severely declined, remove it and replant.

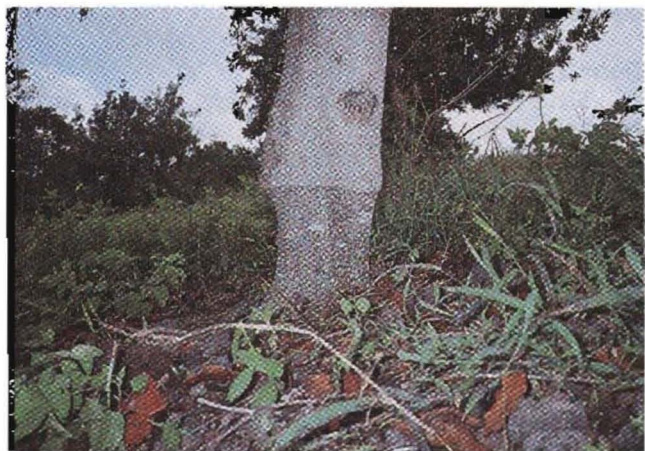


Fig. 9. Trunk shows rough-shell rootstock overgrown by smooth-shell scion. H. C. Bittenbender photo.



Fig. 10. Inarched smooth-shell seedlings strengthen the tree. Photo courtesy of Leng Chia.

PROBLEMS ON BRANCHES OR ENTIRE TREES

Poor Tree Shape

This is a serious problem. A narrow angle between the scaffold (main branch) and leader (trunk), called the crotch angle (Fig. 11), and too many scaffold branches at the same place weakened the tree (Fig. 12). These trees snap off or suffer severe limb breakage as they mature, particularly in windy areas.

Solution

During the first two to four years in the field, prune trees to a single upright leader. Scaffold branches should be pruned to three per whorl, evenly spaced around the trunk (Fig. 13). By pruning, space branches at intervals of 18 or more inches up the trunk. Root or trunk suckers should be removed as they emerge.

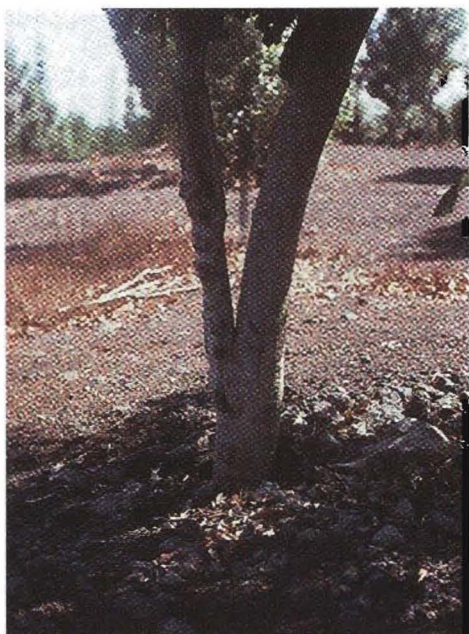


Fig. 11. Double trunk will split because branch angle is too narrow; one should have been removed. Drilling through both trunks and bolting them together with a 1/2-inch-diameter rod or cable may help. Photo courtesy of Mike Nagao.



Fig. 12. Young tree before pruning to space branches properly. Photo courtesy of Mike Nagao.



Fig. 13. Same tree after pruning to space groups of branches and reduce number per group (whorl) to two or three. Photo courtesy of Mike Nagao.

Dieback or Slow Decline

This is a general term for trees with many dead branches. Trees drop leaves at branch ends or older leaves drop too soon, so that only a few leaves are left at the ends of branches (Fig. 14). The condition develops slowly, and there are many causes for this type of dieback.

1. Disease infection in trunk or root system.
2. Prolonged droughts.
3. Anaerobic conditions caused by compaction or poor drainage.
4. Poor root structure caused by planting root-bound trees.
5. Toxic chemicals from herbicides or over-application or uneven application of fertilizers.
6. Nutritional problems.

Dieback related to nutritional problems is common on highly leached soils in high rainfall areas like the Hamakua coast. Acid soils (less than pH 5) interfere with nutrient uptake, particularly phosphorus. Other soils can bind phosphorus so roots can't absorb it. Under these conditions aluminium levels in the leaves may reach toxic levels (greater than 200 ppm).

Solution

Try to determine the cause of the problem by the process of elimination. Proliferation of root suckers generally indicates root, collar, or trunk injury. Phosphorus deficiency usually starts on the main terminals first and works down. General loss of leaves of the entire tree, or confined to particular branches but not necessarily the top, is probably not phosphorus deficiency.

Use soil and tissue analysis, and apply fertilizer and lime as recommended. Before planting a new orchard, have the soil analyzed, and fertilize and lime as recommended.



Fig. 14. In a tree with dieback, upper branches may have few or no leaves. Most new leaves are produced on new branches at the center of the tree. Howard H. Hiraie photo.

Macadamia Quick Decline (MQD)

Leaves quickly turn brown and may stay on the tree (Fig. 15) or all drop immediately; death of the tree is rapid. Currently this problem is more prevalent in high rainfall areas.

Unknown stress factors are suspected to affect the tree and increase its susceptibility to ambrosia beetle attack. Waterlogged soil, low soil pH, nutritional problems, and fungal root and stem rots are suspected stress factors. *Xylaria*, a fungus with black pointed fruiting bodies (Fig. 16), and *Nectria*, a fungus with flat orange fruiting bodies that resemble lantana flowers (Fig. 17), are commonly seen on the trunk.

The role of the ambrosia beetle, *Xyleborus affinis*, is thought to hasten tree decline (Fig. 18). It bores matchstick-sized holes in the trunk, leaving a trail of white powdery wood (frass) on the outside (Fig. 19).

Solution

Don't plant 'Ikaika' (333); it is more susceptible than other cultivars. Dead and dying trees should be removed from the orchard or burned, so that beetles and fungi from infested trees aren't able to reinfest other stressed trees.

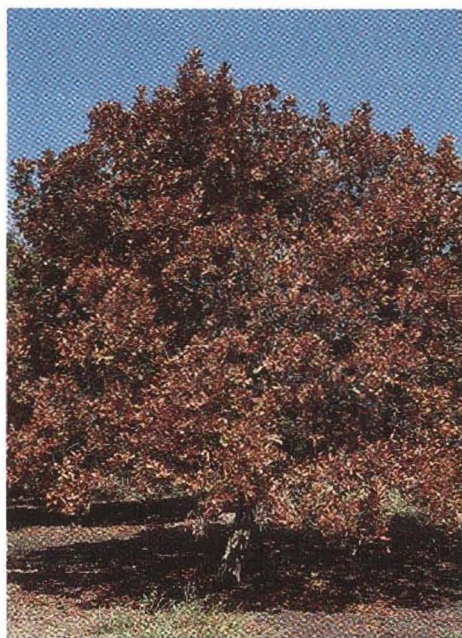


Fig. 15. Tree "firing," or dying so quickly that leaves turn brown and don't drop, is a symptom of MQD. Howard H. Hirae photo.

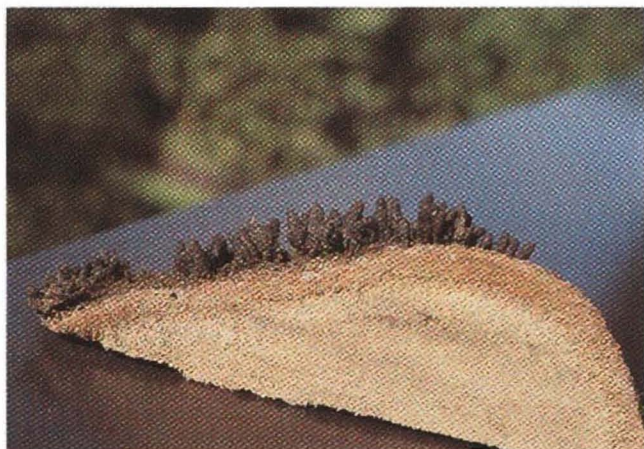


Fig. 16. *Xylaria arbuscula* fungus is frequently associated with MQD. Photo courtesy of Wen Ko.

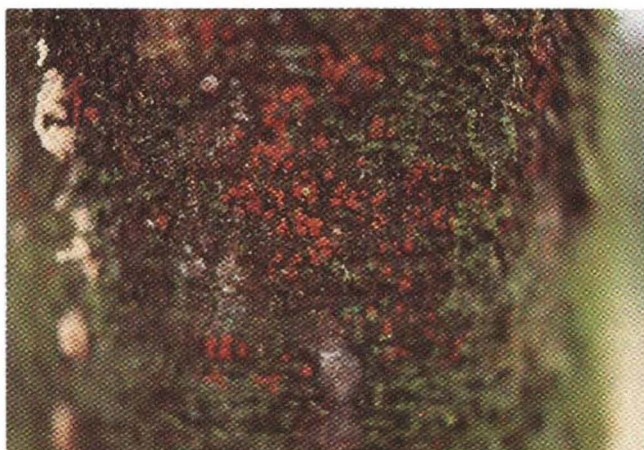


Fig. 17. *Nectria rugulosa* fungus is frequently associated with MQD. Photo courtesy of Wen Ko.



Fig. 18. This adult ambrosia beetle is greatly magnified. Photo courtesy of Arnold Hara.



Fig. 19. Trunk shows severe attack by ambrosia beetles. Note white powdered wood (frass) on bark; this is produced by the beetle. Photo courtesy of Ron Mau.

PROBLEMS ON LEAVES AND YOUNG SHOOTS

How to Collect Leaves for Tissue Analysis

Semiannual tissue analysis is recommended to determine the best fertilizer practice for your orchard and to prevent nutritional problems. It is important to choose the correct leaves for analysis and to understand the results on the laboratory analysis report or "Elemental analyses of plant tissue by ADSC, CTAHR" form. Symptoms of common nutritional problems are discussed later.

Solution

If you've never taken a leaf or soil sample, talk with your extension agent or fertilizer representative before beginning. If your orchard appears normal, sampling one tree per acre is enough. Collect a leaf sample before trees produce new leaves, generally during February and March or before fertilizing in September or October. Pick three to four branches when the bud at the tip of branch is just opening and beginning to grow. Don't be fooled by buds with long, hard red scales called false flushes; they may not open for months (Fig. 20). Buds at the proper stage will have three small, pale green leaves 1/4 to 1/2 inch long; they look like a claw (Fig. 21). If you wait too long, the bud will open completely and turn green, and the new shoot and leaves will be easy to see. Pick one healthy leaf from the second node (whorl) of leaves below the bud. Fifteen leaves from four to five trees are needed for each sample submitted for analysis. Place the leaves in a plastic bag and label the bag with your name, date of sampling, and sample number.

Element concentrations adequate for growth of bearing macadamia trees

<i>Element</i>	<i>Symbol</i>	<i>Concentration (%)</i>
Nitrogen	N	1.45-2.00
Phosphorus	P	0.08-0.11
Potassium	K	0.45-0.60
Calcium	Ca	0.65-1.0
Magnesium	Mg	0.08-0.10
Sulfur	S	0.24 or a N:S ratio between 9 and 14
		<i>Concentration (ppm*)</i>
Manganese	Mn	50-1500
Iron	Fe	50 or a Fe:P ratio > 600**
Copper	Cu	4
Zinc	Zn	15-20
Boron	B	40-100
Aluminum	Al	less than 200

*ppm means parts per million or one ten-thousandth of 1% in oven-dried leaves.

**As ppm/%, e.g. 50 ppm/0.08% = 625.



Fig. 20. In a false flush, the terminal bud isn't growing. Note hard red, leaflike scales. Photo courtesy of Mike Nagao.



Fig. 21. In a true flush, the terminal bud is growing. Note very small new leaves are pale green. This is the proper stage to sample leaves. Photo courtesy of Mike Nagao.

Iron Chlorosis

The typical symptom is new leaves that are pale yellow to white; older leaves are green (Fig. 22). This problem is common in 'a'ā soils that have pH greater than 6.5 or are overfertilized with phosphorus. Trees growing in other soils under similar conditions can develop this problem.

Nursery stock may develop symptoms when excessive amounts of high phosphorus fertilizer such as 10-30-10 are used.

Solution

Stop phosphorus fertilization until symptoms disappear. Semiannual leaf-tissue analysis can be used to monitor leaf phosphorus (P) and iron (Fe) levels. If the Fe:P ratio is less than 600, iron chlorosis is present or will develop. For example, in the table on page 18, the Fe:P ratio is 50 ppm divided by 0.08 percent, or 625. (See Hue and Nakamura, 1988, *Macadamia chlorosis by phosphorus and iron fertilization*, Proceedings of the 28th Annual Meeting, Hawaii Macadamia Nut Association).

In nurseries, foliar application of a 1 to 3 percent iron sulfate solution may relieve symptoms if plants are sprayed several times at two-week intervals.



Fig. 22. Youngest leaves are pale yellow; mature leaves are normal green color. H. C. Bittenbender photo

Magnesium (Mg) Deficiency

Yellow older leaves with wide green veins (interveinal chlorosis) are typical symptoms (Fig. 23). Leaf-tissue analysis shows Mg levels less than 0.065 percent. Dry weather or 'a'ā soils under high rainfall conditions favor this problem. Overapplication of calcium or potassium fertilizers may cause Mg deficiency.

Mg deficiency had no effect on the growth of seedlings 26 months after symptoms appeared (Bowen, 1987, Micro-element nutrition of macadamia, Proceedings of the 27th Annual Meeting, Hawaii Macadamia Nut Association). We think its effect on yield is minimal.

Solution

Use tissue and soil analysis to confirm that a deficiency exists. Apply dolomitic lime or magnesium sulfate according to soil analysis results. Symptoms on affected leaves won't go away. When the deficiency is eliminated, new green leaves will mask and replace affected older leaves.



Fig. 23. Youngest leaves have green veins, but area between them (interveinal) is yellow. H. C. Bittenbender photo.

Glyphosate (Roundup™) Injury

Early symptoms are dead or yellow leaves; the bark of green stems may crack. New growth is quite unusual. Many shoots begin to grow at the end of branches or tops of young trees (Fig. 24). The tree or branch has a bushy appearance. New leaves may be stunted, narrow, and pale. Injury is caused by spray drifting onto green foliage or heavy application in porous soils.

Solution

Branches or young trees generally survive and return to normal growth. If the excess shoots stay and a new, single stem doesn't take over within a year, prune off excess shoots. Severely affected young trees may stay stunted for months to years, and replanting may be necessary. Be extremely cautious when applying herbicides around young trees. Avoid spraying on windy days or soaking weeds down in porous soils. FOLLOW THE LABEL.



Fig. 24. New growth at end of branch or top of young tree is producing many small shoots with narrow leaves instead of normal growth and leaves. Howard H. Hirae photo.

Black Citrus Aphid

Young and adult aphids suck the sap of young leaves (Fig. 25) and flowers (Fig. 26), causing a distortion or puckering of the leaves. Under normal conditions, yields aren't reduced.

Solution

Generally, enough natural predators are present to prevent serious damage.



Fig. 25. Aphids feeding on leaves. Leaves are distorted compared to normal leaves. Photo courtesy of Ron Mau.



Fig. 26. Aphids are feeding on raceme of unopened flowers; the raceme below didn't set nuts. Howard H. Hirst photo.

PROBLEMS ON FLOWERS

Poor Flowering

The intensity of flowering isn't the same every year. In years when the flowering period is quite long, with no distinct period of heavy flowering, growers call this a poor flowering. Growers commonly call a concentrated or heavy flowering period a good flowering (Fig. 27).

Research shows that tree yields are the same whether flowering is "good," many nuts set, and many drop prematurely, or whether flowering is "poor," few nuts set, and few drop prematurely.

Solution

This isn't really a problem. (See Nagao, 1988, Flowering, nut set and premature nut drop of macadamia, Proceedings of the 28th Annual Meeting, Hawaii Macadamia Nut Association. See also Premature Nut Drop on page 31.)



Fig. 27. "Snowball," or intense flowering, doesn't mean yield will be as good as or better than a normal flowering scattered over several weeks. Photo courtesy of Mike Nagao.

Flower Blights

A brown withering of the flowers and racemes is caused by two different fungi: *Phytophthora capsici* causes phytophthora blight (Fig. 28), and *Botrytis cinerea* causes botrytis blight (Fig. 29). A third fungus, *Cladosporium*, is usually secondary or found affecting only the raceme tips. Heavy continual rain and cool temperatures during flowering are ideal conditions for development of these diseases.

Infection is usually scattered within the tree and stops when the weather becomes drier. Phytophthora blight is more common in closed-in orchards, attacking all flower stages and young developing nuts, while botrytis blight is more common on opened flowers.

Solution

Fungicides are available but seldom improve yield. Dry weather or reduced rainfall generally ends the infection. If the problem persists, opening the orchard by pruning or removing trees to improve air circulation may help. Don't plant closer than 25 by 25 feet in high rainfall areas.

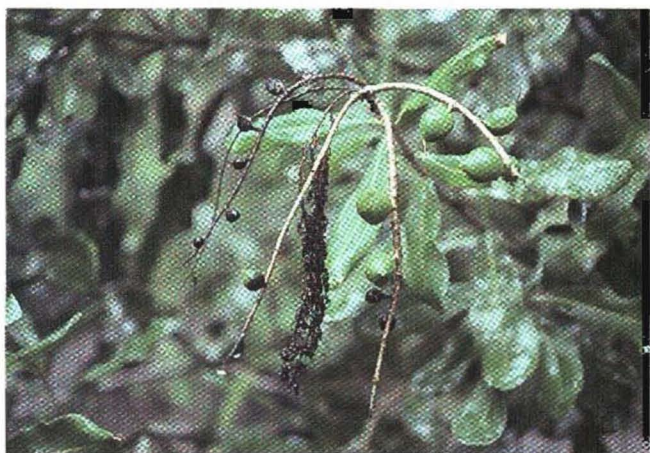


Fig. 28. Phytophthora-killed racemes and young nuts are dark brown. Photo courtesy of Wayne Nishijima.

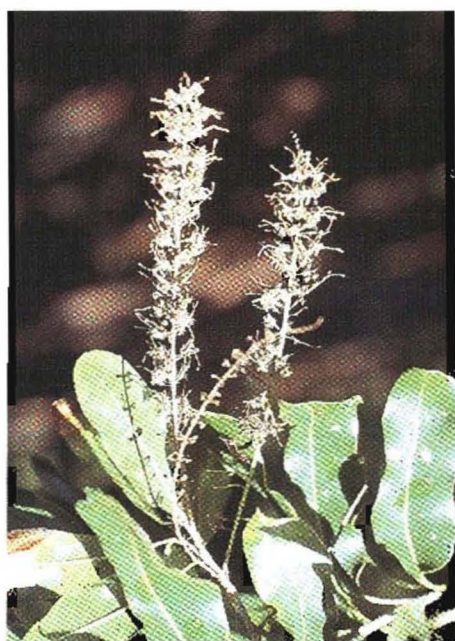


Fig. 29. Botrytis-infected racemes are light brown and cottony; healthy ones are pale green. Photo courtesy of Wayne Nishijima.

Broad Mite

The broad mite, *Polyphagotarsonemus latus*, damages leaves (Fig. 30), flowers, and nuts. Flower buds and unopened flowers may turn brown (Fig. 31) and young nuts drop. Husks of large nuts may be russeted or bronzed, but this doesn't affect the nut (Fig. 32). This pest has a wide host range that includes many weeds and doesn't appear to affect macadamia yield under normal mite populations.

Solution

Monitor flower buds for damage every week or two and spray wettable sulfur if you see a rapid increase in mite damage. Eliminating weed hosts around the orchard should also help. (See also Premature Nut Drop on page 31.)



Fig. 30. Broad mite damage is visible on leaf, while branch on left is normal. Photo courtesy of Ron Mau.



Fig. 31. Broad mite damage is visible on unopened flowers, while those at top are normal. Photo courtesy of Ron Mau.

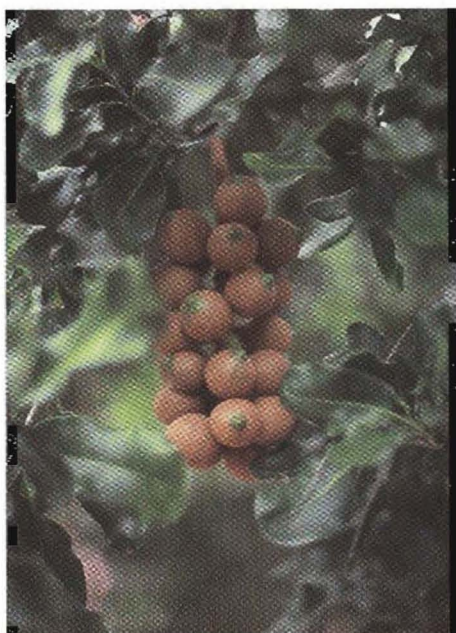


Fig. 32. Mites feeding on nuts cause a bronze russetting of husk, but damage isn't serious at this stage. Photo courtesy of Ron Mau.

Katydid

Two long-horned grasshoppers, *Conocephalus saltator* and *Elimaea punctifera*, occasionally cause damage to macadamia blossoms. Normally, these katydids eat other insect pests, but they can damage unopened macadamia flowers, young shoots, and leaves. Though only the tips of flowers look damaged, they won't set nuts (Fig. 33).

Katydid eat at night and hide in macadamia leaves during the day. If you rustle the branches, they'll fly out.

Solution

Weed control around the trees will help. Damage is usually not serious enough to warrant spraying, but malathion is effective. FOLLOW THE LABEL.



Fig. 33. Katydid feeding damage is visible on unopened macadamia flowers; undamaged flowers are at the right. Photo courtesy of Hiroshi Ooka.

PROBLEMS ON NUTS AND KERNELS

Premature Nut Drop

Most fruit and nut trees, including macadamia, have a tendency to drop fruits at almost any stage of development. The most common time for premature nut drop is soon after nut set when nuts are generally pea sized or smaller (Fig. 34). In Hawaii, this is from March through June. In temperate fruit- and nut-growing areas of the northern hemisphere, it occurs in June; hence, the term "June drop."

Other nuts that are dropped prematurely close to harvest appear normal and are often harvested. During processing these premature kernels, called "immatures" or "shriveled nuts," must be discarded. They may be wrinkled, spongy, or discolored (Fig. 35). These are poor quality; they sink in water. Low oil and high sugar content make the kernels dark colored when roasted.

Many factors influence how many nuts will drop. Drought, cold, heat, waterlogging, cloudiness, nutritional imbalance, injuries, and disease and pest infestation can increase premature drop. Each tree regulates the size of the crop it can bear without damaging the tree by dropping nuts, even when no pests or diseases are present.

Solution

Most premature drop is normal. Regularly check development of the crop. Pests such as stink bug and koa seed worm should be controlled if possible. If you suspect that stress, such as poor nutrition or drought, is reducing yield, try to correct the condition.



Fig. 34. Small and medium premature nuts are on the ground. A few larger prematures will continue to drop until harvest. Photo courtesy of Mike Nagao.

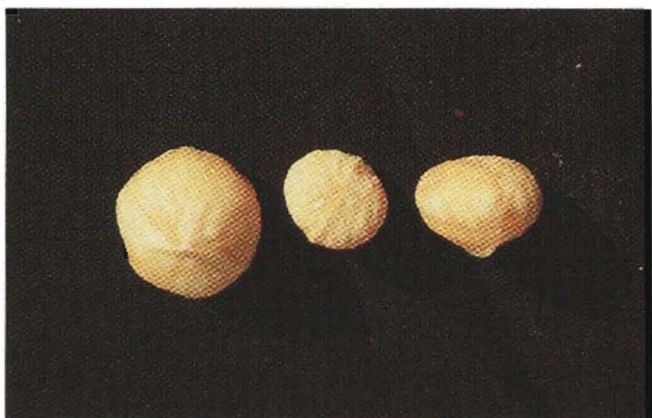


Fig. 35. Dried premature kernels sink in water. They may appear wrinkled or leathery like these. H. C. Bittenbender photo.

Southern Green Stink Bug

This sucking insect, *Nezara viridula*, is a serious pest that attacks young and mature nuts (Fig. 36). Symptoms aren't easily detected until the nuts are dried and cracked. Pits on the kernel are typical signs of stink bug damage (Fig. 37). Damaged kernels may become moldy before harvest. Early heavy infestation may increase premature nut drop.

Solution

Remove host plants from the orchard, particularly members of the bean family. Plant rattle pod (*Crotalaria*) on the borders of the orchard (Figs. 38 and 39). It provides a favorite food for the stink bug and encourages stink bug parasites. Don't let the rattle pod die in the dry season, however. Stink bugs will move from the dead rattle pod into the orchard and feed on the nuts.

Parasites of the stink bug have been released throughout the state by the Hawaii Department of Agriculture. An egg parasite, *Trissolcus basalts*, and an adult parasite, *Trichopoda pennipes*, are the most common. If stink bug parasites are available, releasing them in the border areas and orchard may be effective if the release is made before major damage is seen. Research is needed to determine whether properly timed release of stink bug parasites is cost effective. Macadamia trees can be sprayed with endosulfan or malathion. FOLLOW THE LABEL. (See also Insect Control on page 18 of Macadamia Industry Analysis Number 4, 1988.)

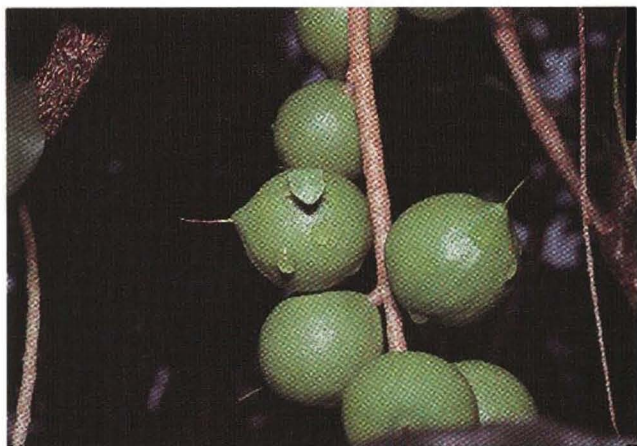


Fig. 36. Adult Southern green stink bug is feeding on the kernel through the husk and shell before harvest. Photo courtesy of Ron Mau.

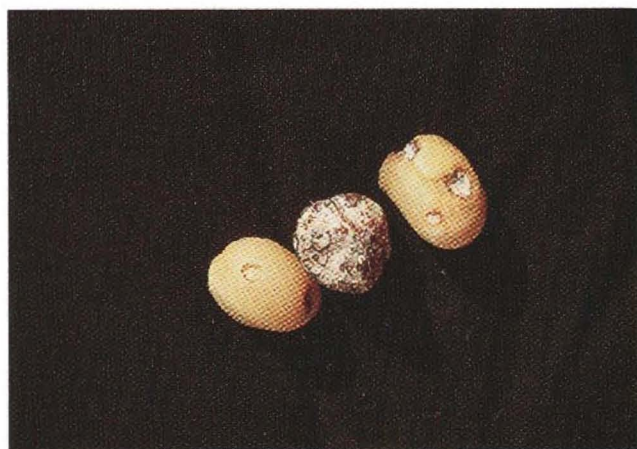


Fig. 37. Dried kernels show typical pitting made when the nut was still on the tree. Kernel in center has mold and yeast growth introduced by stink bug during feeding. H. C. Bittenbender photo.

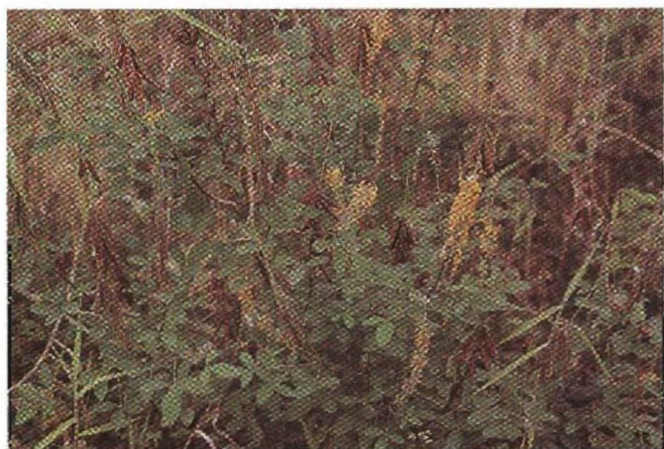


Fig. 38. Smooth rattan pod is growing outside the orchard. Howard H. Hiraie photo.

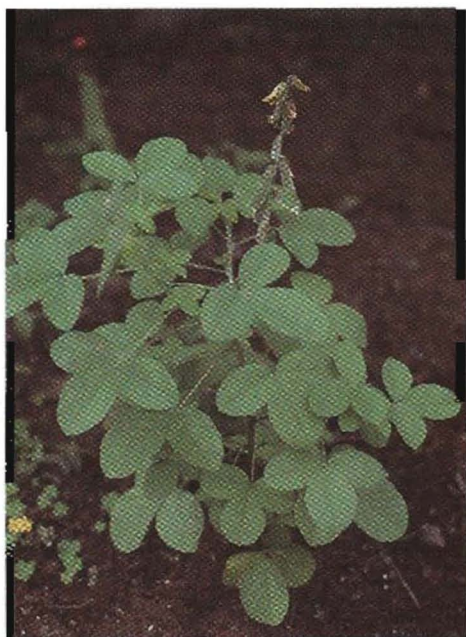


Fig. 39. Close-up of fuzzy rattan pod in flower and fruit. Stink bugs will feed here and parasites will feed on them. Howard H. Hiraie photo.

Koa Seed Worm

The caterpillars (larvae) of this moth, *Cryptophlebia illepidia* (Fig. 40), and of a related species, *C. ombrodella*, the litchi fruit moth (in Australia called the macadamia nut borer), are serious pests. They eat through the husk and shell (Fig. 41) or enter the kernel through natural holes (the hilum and occasionally the micropyle) in the shell. Damaged kernels are recognized by tunneling, frass, and webbing; they may become moldy before harvest (Fig. 42). Early infestation may increase premature nut drop. (See also Insect Control on page 18 of Macadamia Industry Analysis Number 4, 1988.)

Solution

Natural parasites provide some control. Parasites from other countries are being studied, but improvements in the degree of control may not be cost effective. Spraying with endosulfan must be timed accurately with the increasing population, limiting its cost effectiveness. An insect attractant (Isomate-M®) has been registered for use to trap and confuse male moths. Research is under way to determine its cost effectiveness alone and as a tool to predict when spray applications would be most effective.

Preventive measures include using cultivars that have a short harvest season (in your area), and better sanitation, such as removing infested nuts, husks, and prematures from the orchard.



Fig. 40. Adult koa seed worm moth. Photo courtesy of Ernest Yoshioka; original taken by Ron Mau.



Fig. 41. Koa seed worm larva feeding on husk in a macadamia nut. Photo courtesy of Ron Heu.



Fig. 42. Damage is visible on dried kernels. Note irregularly shaped holes on the left kernel, and webbing, feces, mold, and yeast growth on the right. H. C. Bittenbender photo.

Macadamia Shothole Borer

This very small beetle, *Hypothenemus obscurus*, is a newly introduced pest and is potentially serious in dry areas (Fig. 43). Macadamia shothole borer (MSB) commonly attacks macadamia stick-tights in Costa Rica. Little is known of its biology in Hawaii; it was first found in central Kona in 1988.

It bores a pinhole (smaller than that of the koa seed worm) through the shell and lays eggs in the kernel (Fig. 44). The larvae feed and become adult beetles, then eat pinhole-sized tunnels in the kernel and through the shell (Fig. 45). Nuts can be attacked on the tree, on the ground, or during in-shell storage. Damaged kernels can become moldy before harvest. Stick-tights are frequently infested.

Solution

Sanitation and frequent harvesting are important to prevent MSB attack. Take harvested nuts to the processor as soon as possible. Don't sort and leave MSB-infested nuts in the orchard or near nut storage areas, because damaged nuts may contain MSB. Take all harvested nuts to the processor. Just because a shell has MSB holes, that doesn't mean the kernel is damaged. If you do sort out damaged nuts, either bury them at least 3 feet below ground or burn them. No pesticides are recommended at this time.

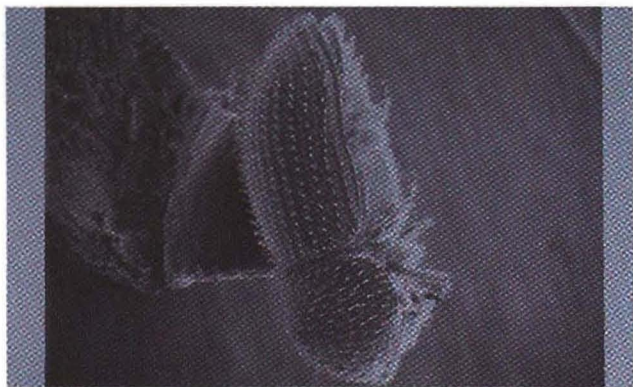


Fig. 43. Close-up of adult macadamia shothole borer. Photo courtesy of Jack Beardsley.

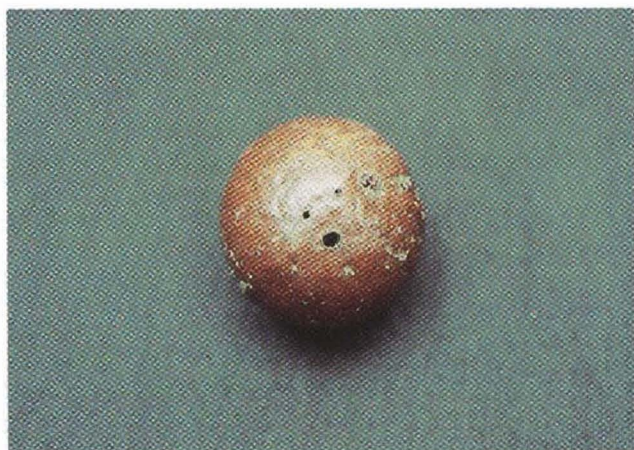


Fig. 44. Nut with holes in shell eaten by koa seed worm (larger) and macadamia shothole borer (smaller two). The hilum, a normal hole in shell through which insects and mold can enter, is at upper right. H. C. Bittenbender photo.



Fig. 45. These dried kernels show pinhole damage; adult beetle is small black speck on clean kernel (upper left). Molds and yeasts carried by the beetle can also attack the kernel. H. C. Bittenbender photo.

Rats and Pigs

Rats attack young nuts in the tree and nuts on the ground. They chew holes 1/4 to 1/2 inch in diameter through the shell and eat the kernel (Fig. 46). Three species attack macadamia. Most damage is done by black rats, which spend much of their time in trees.

Wild pigs consume the entire nut, leaving only small pieces of shell and husk (Fig. 47). They're a problem in orchards near forested areas.

Solution

For rats, remove brush piles in orchards and borders; use rat bait stations throughout the year, especially if nests are spotted in the trees and you find damaged nuts. Don't let the bait get wet; this reduces its effectiveness. FOLLOW THE LABEL. Encouraging owls may be of some benefit, but they will not eliminate a severe rat problem.

For pigs, keeping dogs is helpful. Electric fencing and trapping may be necessary.

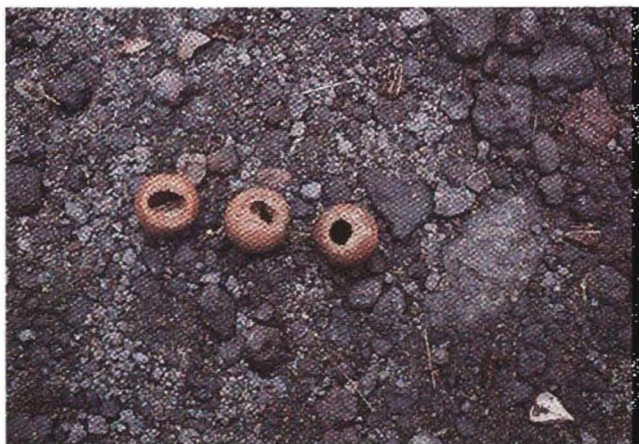


Fig. 46. Rats can chew holes through shell, leaving tiny teeth marks and empty shells. H. C. Bittenbender photo.



Fig. 47. Crushed shells on orchard floor are a clear sign of pig damage. H. C. Bittenbender photo.

Stick-tights

Nuts that don't drop when mature but hang on until knocked down are called stick-tights (Fig. 48). This is caused when a small layer of cells called the abscission zone isn't produced as the nut matures. Why some nuts don't produce an abscission zone is unknown. Drought, other environmental stresses, koa seed worm, anthracnose, and red and black flat mites have been suggested as possible factors.

The cultivar 'Kakea' (508) produces more stick-tights than other cultivars. Despite the stick-tights, 508 has high yields. In areas where macadamia shothole borer becomes common, stick-tights may lead to higher levels of damage.

Solution

No solution is known. The problem of stick-tights does not appear to have an economic effect on yield, however. If you want to knock them down, do it at the end of harvest before they become too old and damaged by the macadamia shothole borer.



Fig. 48. Stick-tight nuts on tree. Howard H. Hirae photo.

Poor Management of Harvest and Postharvest Handling

Nuts will spoil or start to germinate if they're not picked up within a reasonable length of time after dropping. There are several stages and ways in which nuts spoil after dropping. The time before harvest is longest for late and early season nuts. These nuts remain on the ground longer because growers wait for enough nuts to drop before picking. Every extra day a nut is on the ground increases the chance that a pig, rat, or shothole borer will attack. Nuts lying on the ground in wet shaded areas will eventually germinate, begin to rot, or become moldy (Fig. 49). Fungi and bacteria, even ants, enter the shell through natural holes (the hilum and occasionally the micropyle). Germinating nuts are bitter and undesirable for processing.

Another common mistake is storing unhusked nuts in bags or boxes for several days before taking them to the processor (Fig. 50). Husks become moldy and the kernels ferment. Although the kernels may not look moldy, they'll begin to smell bad; these kernels can't be eaten. Stale kernels may look normal, but they won't taste good.

Solution

Keep spoilage records each year. Each grower must decide when losses resulting from moldy, germinating, and rat- and pig-damaged nuts cost more than the extra labor cost of picking more frequently. The rule of thumb is to pick at least every four weeks in rainy weather and less often in dry weather.

Never store unhusked nuts more than one day in a bag or box. If you don't want to take a small load to the processor, and the rats and pigs aren't too bad, it's better to leave the nuts in the orchard. If the nuts were picked but can't be delivered to the processor and you can't husk them, then dry them. Spread the in-husk nuts to dry on a wire or slotted rack out of the rain and direct sun. It's best to husk nuts immediately and air dry them or take them to the processor the next day.

Don't mix old unhusked or husked nuts with freshly harvested nuts or ship them as the same lot to the processor. The poor quality of a single bad bag might ruin the sampling for an entire load. Remember, when you lose quality you lose money.

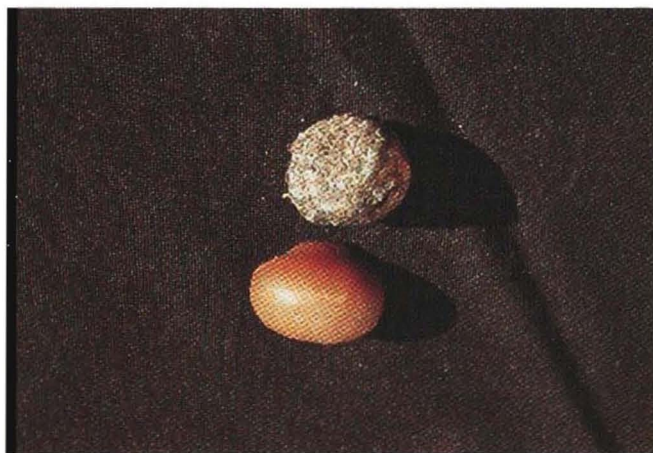


Fig. 49. Mold- and yeast-damaged kernels left in the orchard too long after dropping. The in-husk nuts weren't moldy; they looked normal. H. C. Bittenbender photo.

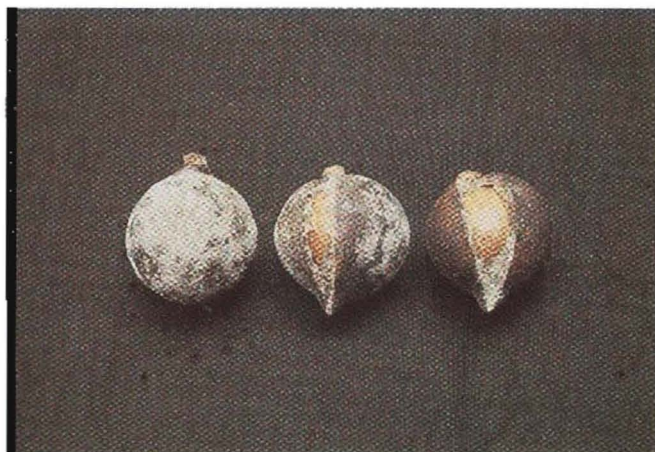


Fig. 50. Fresh in-husk nuts are moldy after being in a closed box for just a few days. The kernels look normal, but they smell bad. H. C. Bittenbender photo.

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